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Linear long wave propagation over discontinuous submerged shallow water topography

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ABSTRACT

The dynamics of an isolated long wave passing over underwater obstacles are discussed in this paper within the framework of linear shallow water theory. Areas of practical application include coastal defense against tsunami inundation, harbor protection and erosion prevention with submerged breakwaters, and the construction and design of artificial reefs to use for recreational surfing. Three sea-floor configurations are considered: an underwater shelf, a flat sea-floor with a single obstacle, and a series of obstacles. A piecewise continuous coefficient is used to model the various sea-floor topographies. A simple and easily implementable numerical scheme using explicit finite difference methods is developed to solve the discontinuous partial differential equations. The numerical solutions are verified with the exact analytical solutions of linear wave propagation over an underwater shelf. The scope of this simplified approach is determined by comparison of its results to those of another numerical solution and wave transmission and reflection coefficients from experimental data available in the literature. The efficacy of approximating more complicated continuous underwater topographies by piecewise constant distributions is determined. As an application, a series of underwater obstacles is implemented.

1. Introduction

The study of water waves over variable underwater topography has numerous practical applications. Underwater reefs are built for several purposes including the generation of ideal waves for recreational surfing, protection from harbor damage and beach erosion, and the defense against destructive tsunami waves. Tsunamis are formed by rapid displacement of large masses of water, typically due to underwater earthquakes or volcanic activity [1,13]. As a tsunami wave approaches the shallow shorelines near a beach from deep water, its amplitude increases and its wavefront steepens; this is one source of its destructive potential. Studying the relationship between shallow water topography and the amplification of long waves that travel shore-wards can help us construct models that accurately predict the effects of tsunamis near coastal zones. These models can help us assess the efficacy of man-made structures in dampening the waves' destructive effects.

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